An Expendable Source for Measuring Shallow Water Acoustic Propagation and Geo-Acoustic Bottom Properties

Harry A DeFerrari
RSMAS – University of Miami
4600 Rickenbacker Causeway
Miami FL. 33149
phone: 305 421 4644 fax: 305 421 4701 email: hdeferrari@rsmas.miami.edu

Award Number: N00014-C-0080/2

LONG-TERM GOALS

An expendable broadband source is being developed that transmits high gain m-sequence to clandestinly measure pulse response of shallow water acoustic propagation channels.

OBJECTIVES

Acoustic propagation models need ground truth comparisons to give reliable predictions – especially in denied areas with limited information about the ocean acoustic environment and the geo-acoustic properties of the bottom. The objective here is to measure the pulse response in shallow water by deploying expendable sources that are received with AUV or towed arrays. The data can then be used to tune propagation models and estimate the geo-acoustic properties of the bottom by inversion.

APPROACH

M-sequences have long been the workhorse of basic research experiments on coherence of acoustic propagation. They provide high gain and precise pulse response measurement with "zero" leakage – the only signal that does. Sources are being developed by STTR partners and UM provides the signal processing and data analysis. An experiment in shallow water near Jacksonville is planned.

WORK COMPLETED

Software for generating and processing (pulse compressing) m-sequences using Hadamard Transforms has been adapted for this application. Also, Doppler processing of received signals from moving platforms has been developed and tested.

Modelling forward transmission for the proposed experimental site has been completed . Sensitivity of the predicted pulse response to geo-acoustic parameters that describe bottom is underway. Attempts at inversion will follow once data is in hand.

RESULTS

Signal Processing:

M-sequence pulse compression with Hadamard transform including Doppler compensation is complete. It is adequate for the problem at hand but additional processing has been included for two other potential applications of the expendable source; 1. A "see-through" jamming source and 2. A multi-static continuous active m-sequence sonar (CAMS). Both applications employ a type of processing called HCC0 (H. Chang, 1996). HCC0 processing works as follows. First the incoming data from the off-board source(s) are sampled at precisely an even multiple of the carrier frequency. Such samples can then be regrouped to comprise a Complete-Ortho-Normal (CON) set that defines the m-sequence in a waveform space. Each set of the group is then pulse compressed by Hadamard Transform to form exactly one point of the pulse compresses m-sequence. These points also are a CON set that defines the pulse response in an arrival time space. Now, if one sets a pulse point to zero and transforms back to waveform space (inverse Hadamard Transform) one ends up with the undistorted original waveform except that the m-sequence is completely and totally removed. Removing m-sequences with HCC0 processing results in a completely transparent or "see through " jamming signal and the elimination of zero Doppler direct arrivals and bottom reverberation arrivals with all of their Doppler leakage (clutter) allowing for target detection in a noise limited Doppler–Time plane.

Forward Modelling and Sensitivity to Bottom Model Parameters:

We use the broadband parabolic equation model MMPE. In four previous experiments, including SW06, this model gave very close agreement with measurements. MMPE is being used to predict the pulse responses of the the planned experimental propagation channel site near Jacksonville, FL.

Several parameters define the geo-acoustic properties of the two layer bottom of MMPE – for example, bottom sound speed, density, gradient, absorption,etc. We have examined the relative strength of the effect on the spread and intensity of the pulse response as it evolves with range. Figure 1 shows the calculation for changes in sounds speed at the water-sediment boundary. Cearly, this is a first order effect that allows higher order modes to propagate resulting in pulse spreading. Likewise density is a first order variable whereas graident in both the top and bottom layer seem to have a relativly negligable effect.

With data for the planned experiment, we can evaluate the feasibility and resolution of a detailed inverion

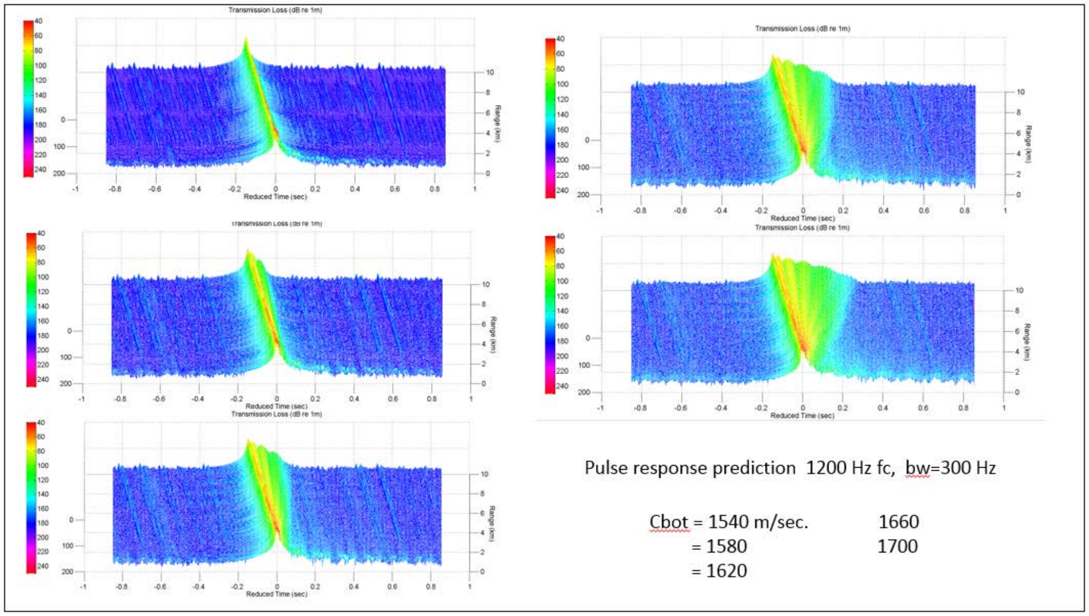

Figure 1. Pulse dispersion out to 10 km for each of 6 values of the bottom sound speed.

IMPACT/APPLICATIONS

M-sequence pulse compression with Hadamard transform including Doppler compensation is complete processing has two other possible applications of the expendable source; 1. A "see-through" jamming source and 2. A multi-static continuous active m-sequence sonar (CAMS). Both applications are being persued.

RELATED PROJECTS

None

REFERENCES

1. Henry S. Chang, (**1992**) "Detection of weak, broadband signals under doppler-scaled, multipath propagation", PhD Thesis, , Electrical Engineering: Systems, University of Michigan.

2. Harry.A. DeFerrari and A.K. Rogers (**2009**) , "Reducing Active Sonar Levels by Continuous Transmit and Receive Operation," JUA 59, 5-18 (2009).

PUBLICATIONS

An Expendable Acoustic Source (EAS) for Projecting Continuous M-Sequence Waveforms Simultaneously Used as a Sonar Countermeasure with True Look-Through Capability, and a Bi-static Source Providing One-Way Range Measurements. (U) Sassler, A.T, DeFerrari, H, Rorick, T. and Donoher, G. STS -2015 [published, refereed]